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Significant Range Expansions in Eight Species of North American Mammals

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Abstract

Extralimital records have been noted for several mammals in North America at local scales, but it is yet to be determined how the entire geographic distribution has changed for many of these species. Updated distributions are provided for eight species of mammals that are broadly expanding their ranges in North America. Distributional data was collected from museum records and published literature for an initial group of mammals that showed evidence of range expansions. This list was reduced to species that were expanding in three or more states/provinces and where an updated distribution had not been published in the past 20 years. Eight species of mammals were identified using these criteria. Three species show movement in an overall westward direction, two are moving north, one is moving west and north, and one each is moving east and south. Monitoring changes in species distributions is important for identifying novel ecological interactions and predicting potential routes of disease spread.

Key words: *Baiomys taylori*, *Cryptotis parvus*, *Erethizon dorsatum*, *Marmota monax*, *Mustela nivalis*, *Myotis septentrionalis*, *Nycticeius humeralis*, range expansion, *Sigmodon hispidus*

Introduction

A topic that has generated significant interest in the field of biogeography has been the expansion of geographic ranges by numerous species (Parmesan and Yohe 2003; Hickling et al. 2006). Among the most well-documented groups include birds (Thomas and Lennon 1999; Probst et al. 2003; Root et al. 2003), butterflies and other insects (Thomas et al. 2001; Chen et al. 2011), marine fishes (Last et al. 2011), marine invertebrates (Southward et al. 1995; Sagarin et al. 1999; Zacherl et al. 2003; Rivadeneira and Fernández 2005), and mammals (see below). Factors driving these expansions appear to be recent changes in climate (Parmesan et al. 1999; Thomas 2010) and/or human alterations to landscapes (Gilchrist et al. 2015; Walsh and Tucker 2018). Monitoring changes in species distributions is important because as species disperse into new areas, novel ecological interactions are inevitable (Alexander et al. 2015). Additionally, species range expansions can facilitate the spread of wildlife diseases (Roy-Dufresne et al. 2013).

Range expansion among mammals often has been reported in the literature. For example, Myers et al. (2009) documented northward expansions of four mammals in the northern Great Lakes region. In Nebraska, Benedict et al. (2000) reported new distributional

records for 20 species of mammals with new records occurring beyond previous range limits in all cardinal directions. Frey (1992) noted that four mammals of the boreal faunal element recently had expanded their ranges southward onto the Great Plains. Out of the 15 species of bats that occur in Kansas, Sparks and Choate (2000) provided evidence that nine species had undergone noteworthy range expansions, with most expanding their range to the west and north. In addition to those reports, numerous extralimital records have been observed for several species. Much of the evidence for range expansions is found in published accounts where new records are noted for specific regions or in unpublished museum records. Whereas those data provide valuable information on species distribution in a specific geographic area, it generally is unclear how the overall geographic range of the species has changed. The objectives of this study were to: 1) identify mammals that are broadly expanding their geographic ranges in North America; 2) compile a dataset of extralimital records for each species; and 3) update each species geographic range limits.

METHODS

The focal species of this study were limited to those that possessed documented range expansions, via peer-review publications or museum voucher specimens, in multiple (≥3) states and/or provinces. This selection criteria eliminated species where only localized range extensions had been documented. Also, species were eliminated if an updated distribution had recently (<20 yrs) been published. Some examples include the Nine-banded Armadillo (*Dasypus novemcinctus*; Taulman and Robbins 2014), Tricolored Bat (*Perimyotis subflavus*; Geluso et al. 2005), Virginia Opossum (*Didelphis virginiana*; Walsh and Tucker 2018), Eastern Red Bat (*Lasiurus borealis*; Solick et al. 2020), and Seminole Bat (*Lasiurus seminolus*; Perry 2018). An exception to this criterion would be if significant records (i.e., state records) had been discovered since the updated distribution was published, as is the case with the Evening Bat (*Nycticeius humeralis*; Andersen et al. 2017).

An initial list of species was generated from Benedict et al. (2000) who noted new distributional records for 20 species of mammals in Nebraska. This provided a good starting point because it included representatives of mammals whose geographic ranges were centered in each of the four general regions (north, south, east, west) of North America and whose range edges converged in central North America (i.e., Nebraska). For each species an internet search was performed using the Google Scholar search tool. Along with the species name, key search terms included "range expansion", "range extension", "range shift", "new records", "distributional records", "extralimital records", "recent records", "state record", and "observations". Once a literature source was identified, the article was scanned for other citations of mammals with expanding geographic ranges. This allowed for the identification of additional range-expanding mammals not listed in Benedict et al. (2000), such as the Northern Pygmy Mouse (*Baiomys taylori*). The Google Scholar search engine also provides a list of publications that had cited a particular article. This list was examined for any relevant literature. Finally, the geographic range of each species as published by Hall (1981) was examined, and adjacent states/provinces that were immediately outside the geographic range of a species were noted. Another literature search was performed using the species name and the state/province as search terms. This was done so that any research whose objectives were not focused on range expansion, but otherwise may have collected a target species, could be identified. A list of focal species was identified based on the criteria listed above and arranged by state/province.

Digital distribution maps (Patterson et al. 2007) for each focal species were downloaded and imported into a GIS to use as reference for determining the extent of range expansion. Maps from this data source were based on those from Hall (1981) or Wilson and Ruff (1999). Only maps by Hall (1981) were used in order to have a consistent starting point for determining extralimital records. In cases where downloaded maps were based on Wilson and Ruff (1999), the polygons were edited in the GIS to match the distributions drawn by Hall (1981). A new map was generated for each species showing its distribution as reported by Hall and Kelson (1959). The two maps (Hall 1981 and Hall and Kelson 1959) were overlaid to show the progress

of range expansion for each species. In the case of *N. humeralis*, an additional map was included showing an updated distribution that was proposed by Andersen et al. (2017). Museum records for each species were downloaded from the Global Biodiversity Information Facility (www.gbif.org). Because the range limit drawn by Hall (1981) was used as a reference, the search was limited to museum specimens collected in or after 1980. These records were separated into categories based on whether they were first reported in a publication or represented an unpublished museum specimen. Finally, this list of specimens was supplemented by any individual record(s) discovered in the published literature that constituted an extralimital record but was not deposited in a museum as a voucher specimen.

Museums from which data were collected included the Angelo State Natural History Collection (ASNHC), Austin Peay State University (APSU), Bell Museum of Natural History (MMNH), California Academy of Sciences (CAS), Carleton University Museum of Zoology (CUMZ), Carnegie Museum of Natural History (CM), Central Missouri State University (CMSU), Denver Museum of Nature and Science (DMNS), Eastern Kentucky University (EKU), Eastern Michigan University, T.L. Hankinson Vertebrate Museum (EMU), Emporia State University (KSTC), Field Museum of Natural History (FMNH), Fort Hays State University Sternberg Museum (FHSM), Kearney State University Vertebrate Museum (VMKSC), Kentucky State Nature Preserves Commission (KSNPC), Louisiana Natural Heritage Program (LNHP), Louisiana State Museum of Natural Science (LSUMZ), Mammal Collections of Midwestern State University (MWSU), Mayborn Museum, Baylor University (BU), Michigan State University Museum (MSU), Morehead State University (MOSU), Murray State University (MSUMC), Museum of Southwestern Biology (MSB), Museum of Texas Tech University (TTU), Natural History Collection at Western New Mexico University (WMNU), Nature Serve (NTSRV), New Mexico Museum of Natural History and Science (NMMNHS), New York State Museum (NYSM), North Carolina State Museum of Natural Sciences (NCSM), Oklahoma State University Collection of Vertebrates (OSU), Oklahoma State University Museum (OKSU), Royal British Columbia Museum (RBCM), Sam Noble Oklahoma Museum of Natural History (OMNH), San Diego Natural History Museum (SDNHM), Southwestern College (SCK), Tennessee Wildlife Resources Agency (TWRA), Texas Cooperative Wildlife Collection (TCWC), University of Alaska Museum (UAM), University of Arkansas Collections Facility (UAFMC), University of Central Oklahoma Collection of Vertebrates (UCOCV), University of Colorado Museum of Natural History (UCM), University of Kansas Biodiversity Institute and Natural History Museum (KU), University of Missouri Museum of Zoology (MUMZ), University of Nebraska State Museum (UNSM), University of Tennessee Forestry, Wildlife, & Fisheries Teaching College (UTFWF), University of Washington Burke Museum (UWBM), University of Wyoming Museum of Vertebrates (UWYMV), Vertebrate Museum at the University of Nebraska at Kearney (VMUNK), and Virginia Commonwealth University Mammal Collection (VCUM).

RESULTS

This study revealed eight species of mammals that have broadly expanded their range throughout North America and whose expansions have not been recently summarized in the literature (with the exception of *N. humeralis* as explained in the Methods). These species included the Least Weasel (*Mustela nivalis*), Northern Long-eared Myotis (*Myotis septentrionalis*), Evening Bat, Least Shrew (*Cryptotis parvus*), Hispid Cotton Rat (*Sigmodon hispidus*), Northern Pygmy Mouse, North American Porcupine (*Erethizon dorsatum*), and Woodchuck (*Marmota monax*). Range expansions were noted in each of the four cardinal directions with the majority of species expanding west ($n = 3$), north ($n = 2$), both west and north ($n = 1$), east ($n = 1$), and south ($n = 1$).

ORDER CARNIVORA
Family Mustelidae
***Mustela nivalis* (Linnaeus, 1766)**
Least Weasel

Mustela nivalis has a circumboreal distribution in the Northern Hemisphere (Sheffield and King 1994). In North America, this species ranges from Alaska

and Canada southward into the United States where it reaches its southern limits in Kansas, Missouri, Illinois, Ohio, North Carolina, and Tennessee (Hall 1981). Although widespread, *M. nivalis* is considered locally rare and never reported in high densities (Erlinge 1974; Goszczynski 1977). Preferred habitats are those that possess an abundance of small rodents and include open forests, cultivated land, riparian woodlands, grasslands, and alpine meadows (Sheffield and King 1994).

Range expansion of *M. nivalis* generally is southward especially in the Great Plains, Southeastern Plains, and Appalachian regions of the United States (Fig. 1). There is also some movement onto the Front Range of Montana and Wyoming most likely through western South Dakota (Mullican 2011) and Nebraska (Benedict et al. 2000). The first published record of *M. nivalis* in Wyoming was reported by Stromberg et al. (1981). Our data search revealed new unpublished records of *M. nivalis* in northcentral, northeastern, and southeastern Wyoming (Fig. 1). The one record from Montana is from a specimen discovered in the scat remains of a Canada Lynx (*Lynx canadensis*; Squires and Ruggiero 2007). Whereas vouchered specimens remain rare throughout southern and western Montana, observations have been reported throughout the state (Montana Natural Heritage Program 2022).

Southward movements of *M. nivalis* in the central United States were first noted in northern Kansas during the mid-1960's (Choate et al. 1979) and in Missouri and Iowa in the early 1970's (Easterla 1970). Consequently, all of northern Kansas and Missouri were included in Hall's (1981) distribution of *M. nivalis*. Since Hall (1981), additional specimens of *M. nivalis* were recorded from central and southern Kansas (Bailey and Terman 1986; Choate et al. 1988; Hoofer and Choate 1997; Kaufman and Kaufman 2010), northeastern Missouri (Mock et al. 2001), and as far south as northeastern Oklahoma (Clark and Clark 1988).

In the eastern United States, extralimital records of *M. nivalis* were first reported in the 1960's from North Carolina (Stupka 1960; Barkalow 1967) and Tennessee (Tuttle 1968). In subsequent years, new records were added in Tennessee (Nagel 1972; Anderson 1988; Cushing and Knight 1991), Kentucky (Prather 1984; David 1988; Campbell et al. 2010), Georgia (Linzey and Hamed 2016), and Virginia (Bellows et al. 1999; Roble and Hobson 2000). Recent work by Linzey and Hamed (2016) used museum records and citizen scientist reports to determine that *M. nivalis* is more abundant and widespread than previously known throughout its range in the southeastern United States.

Previously published museum specimens (29).—GEORGIA: Fannin County: (34.951N, -84.385W), 1 APSU (Linzey and Hamed 2016); KANSAS: Barton County: (38.525N, -98.533W), 1 FHSM (Hoffer and Choate 1997); Butler County: (37.939N, -97.001W), 1 FHSM (Choate et al. 1988); McPherson County: (38.371N, -97.664W), 1 FHSM (Choate et al. 1988); Sedgwick County: (37.783N, -97.167W), 1 FHSM (Choate et al. 1988). KENTUCKY: Bourbon County: (38.217N, -84.228W), 1 EKU (Linzey and Hamed 2016), (38.302N, -84.272W), 2 KSNPC (Linzey and Hamed 2016); Calloway County: (36.640N, -88.285W), 1 MSUMC (Linzey and Hamed 2016); Clark County: (37.990N, -84.180W), 1 KSNPC (Linzey and Hamed 2016); Elliott County: (38.132N, -83.099W), 1 MOSU (Linzey and Hamed 2016); Fayette County: (37.989N, -84.478W), 1 FHSM (Linzey and Hamed 2016), (38.135N, -84.526W), 1 CM (Linzey and Hamed 2016); Fleming County: (38.269N, -83.611W), 1 MOSU (Linzey and Hamed 2016); Lewis County: (38.484N, -83.282W), 1 MOSU (Linzey and Hamed 2016); Madison County: (37.680N, -84.255W), 1 EKU (Linzey and Hamed 2016); Rowan County: (38.059N, -83.465W), 2 MOSU (Linzey and Hamed 2016), (38.065N, -83.483W), 1 MOSU (Linzey and Hamed 2016); Woodford County: (38.151N, -84.684W), 1 NCSM (Prather 1984). OKLAHOMA: Cherokee County: (35.932N, -95.210W), 1 FHSM (Clark and Clark 1988). TENNESSEE: Cumberland County: (35.949N, -85.027W), 1 TWRA (Linzey and Hamed 2016); Fentress County: (36.428N, -84.932W), 1 UTFWF (Linzey and Hamed 2016). VIRGINIA: Caroline County: (38.050N, -77.347W), 1 VCUM (Bellows et al. 1999).

Unpublished museum specimens (11).—KANSAS: Coffey County: (38.142N, -95.576W), 1 KSTC; Ness County: (38.477N, -99.991W), 1 FHSM. NEW YORK: Chautauqua County: (42.435N, -79.378W), 1 NYSM; Wyoming County: (42.8367N, -78.3984W), 1 NYSM. NORTH DAKOTA: Adams County: (46.060N, -102.518W), 1 MSB. SOUTH DAKOTA: Custer County: (43.668N, -103.547W), 2 FHSM.

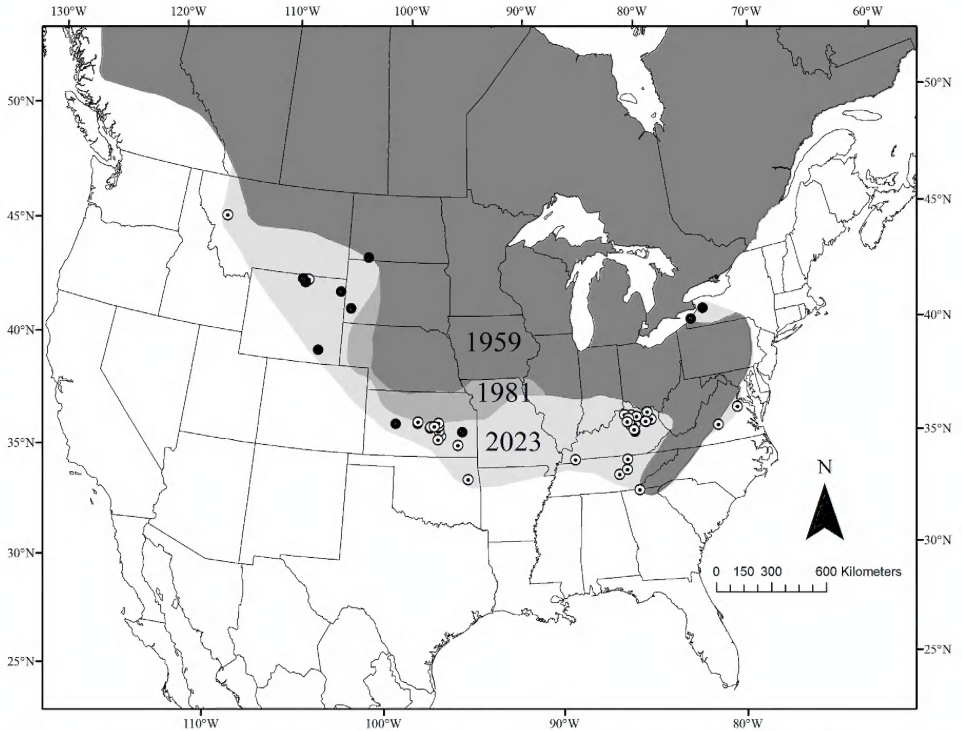

Figure 1. Distribution of the Least Weasel (*Mustela nivalis*) in North America showing the historic range limits proposed by Hall and Kelson (1959) and Hall (1981), as well as the current range (2023). Enclosed circles represent previously published records and black dots represent unpublished museum records.

WYOMING: Albany County: (41.638N, -105.594W), 1 FHSM; Crooke County: (44.411N, -104.357W), 1 UWYMV; Sheridan County: (44.672N, -107.004W), 1 UWYMV, (44.822N, -107.209W), 1 UWYMV.

Literature records reported by Anderson (1988) (1).—TENNESSEE: Cumberland County: (35.763N, -85.560W), 1.

Literature records reported by Bailey and Terman (1986) (6).—KANSAS: Marion County: (38.352N, -97.205W), 2, (38.400N, -97.120W), 2, (38.547N, -97.153W), 1; McPherson County: (38.316N, -97.698W), 1.

Literature records reported by David (1988) (2).—KENTUCKY: Madison County: (37.734N, -84.274W), 1, (37.748N, -84.295W), 1.

Literature records reported by Hoofer and Choate (1997) (3).—KANSAS: Barton County: (38.580N, -98.499W), 1; Marion County: (38.170N, -97.107W), 1; McPherson County: (38.386N, -97.428W), 1.

Literature records reported by Linzey and Hamed (2016) (4).—KENTUCKY: Harrison County: (38.433N, -84.354W), 1; Nicholas County: (38.343N, -84.030W), 1; Owen County: (38.497N, -84.815W), 1; Scott County: (38.317N, -84.564W), 1.

Literature records reported by Kaufman and Kaufman (2010) (1).—KANSAS: Riley County: (37.520N, -95.876W), 1.

Literature records reported by Roble and Hobson (2000) (1).—VIRGINIA: Appomattox County: (37.403N, -78.793W), 1.

Literature records reported by Stromberg et al. (1981) (2).—WYOMING: Sheridan County: (44.797N, -106.956W), 1, (44.813N, -106.774W), 1.

Literature records reported by Squires and Ruggiero (2007) (1).—MONTANA: Missoula County: (47.200N, -113.507W), 1.

ORDER CHIROPTERA
Family Vespertilionidae
***Myotis septentrionalis* (Trouessart, 1897)**
Northern Long-eared Myotis

Myotis septentrionalis is widely distributed throughout the eastern United States and westward to the Great Plains of central United States (Hall 1981). The range of *M. septentrionalis* reaches southward into the panhandle of Florida, but is uncommon in many of the southeastern states such as South Carolina, Georgia, Florida, Mississippi, and Louisiana (Caceres and Barclay 2000). To the north, *M. septentrionalis* inhabits much of southeastern and central Canada. Preferred habitat includes eastern deciduous and boreal forests, where they typically roost in mature trees during summer and hibernate in caves or abandoned mines in winter (Caceres and Barclay 2000). Significant population declines of *M. septentrionalis* have occurred in northeastern portion of its range due to white-nose syndrome, resulting in this species being federally listed as Threatened (Langwig et al. 2012).

Although populations of *M. septentrionalis* have declined in the northeastern portion of their range, this species has been expanding along its western range limit in the United States and Canada (Fig. 2). There have also been some extralimital records noted along the southeastern edge of its distribution. For instance, Morris et al. (2009) captured six individuals of *M. septentrionalis* along the coastal plains of eastern North Carolina, representing a 96 km southern range extension. Later work by Grider et al. (2016) and Jordan (2020) expanded the known records of *M. septentrionalis* to include the entire eastern portion of North Carolina. In South Carolina, White et al. (2018) captured two specimens of *M. septentrionalis* in the farthest southern portions of the state, representing an approximately 350 km range extension.

Myotis septentrionalis also has undergone widespread expansion along the western border of its geographic range (Fig. 2). In southcentral United States, *M. septentrionalis* was collected in central Louisiana in 2000 (Crnkovic 2003), approximately 249 km south of the nearest occurrence in Arkansas. Since this report, additional records have been noted in central Louisiana (Stevens et al. 2017; Hoffman and Chauhan 2020; Stevens et al. 2020) and one record in southeastern Louisiana (Stevens et al. 2017). Braun et al. (2020) documented a range expansion in southeastern Oklahoma. Only one record of *M. septentrionalis* is known from Texas (Schmidly and Bradley 2016). This specimen was collected in southern Texas near the Mexico border in 1942. The early collection date of this specimen compared to all others in this report suggests that this was a lone vagrant (Schmidly and Bradley 2016) and not part of population that was actively expanding its range. Finally, Saugey et al. (1993) and Sasse et al. (2014) have noted several new county records throughout Arkansas.

In the Great Plains of the United States, evidence of range expansion by *M. septentrionalis* is present in Kansas (Sparks and Choate 2000) and Nebraska (Benedict et al. 2000; Johnson and Geluso 2017). Although much of the eastern parts of Oklahoma, Kansas, Nebraska, and the entire upper Great Plains are included within the range of *M. septentrionalis* (Hall 1981), new county records have been recorded in many of those states. For instance, new records of *M. septentrionalis* were collected in eastern Oklahoma (Caire et al. 1989; Clark and Clark 1997; Braun et al. 2020), west-central and northeastern Kansas (Sparks and Choate 2000), both northern (Benedict 2004; Geluso et al. 2015) and southern (Johnson and Geluso 2017; Roehrs et al. 2021) Nebraska, and northeastern Wyoming (Bogan and Cryan 2000; Geluso and Bogan 2018). One record of *M. septentrionalis* was reported from a mine in northeastern Montana (Hendricks 2012). Finally, *M. septentrionalis* is greatly expanding its range in northwestern Canada. Specifically, there are new extralimital records reported throughout Alberta (Caceres and Pybus 1997; Alberta Sustainable Resource Development and Alberta Conservation Association 2009), and eastern British Columbia and southeastern Yukon (Jung et al. 2006; Lausen et al. 2008).

Previously published museum specimens (13).—USA: LOUISIANA: Grant Parish: (31.757N, -92.612W), 1 TTU (Stevens et al. 2017); Jackson Parish: (32.240N, -92.530W), 1 TTU (Stevens et al. 2017),

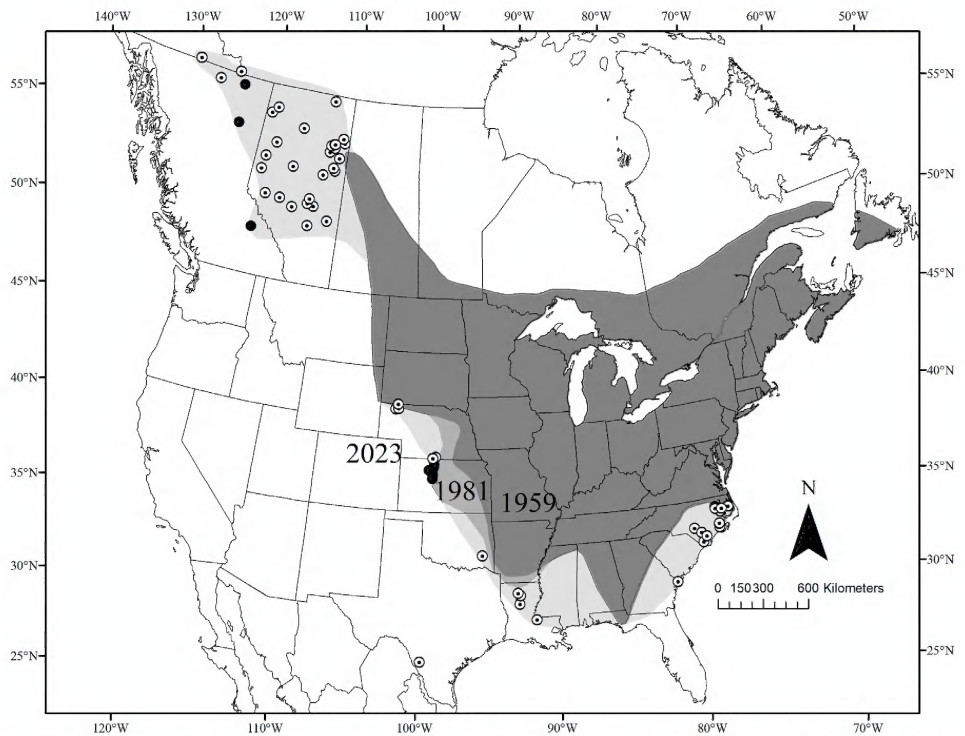

Figure 2. Distribution of the Northern Long-eared Myotis (*Myotis septentrionalis*) in North America showing the historic range limits proposed by Hall and Kelson (1959) and Hall (1981), as well as the current range (2023). Enclosed circles represent previously published records and black dots represent unpublished museum records. The single record from Texas was not included in the proposed distribution given its location and should be considered an extralimital record until more specimens are captured.

(32.384N, -92.707W), 1 LNHP (Hoffman and Chauhan 2020); West Feliciana Parish: (30.840N, -91.400W), 1 TTU (Stevens et al. 2017). NEBRASKA: Franklin County: 40.089N, -99.139W), 1 UNSM (Johnson and Geluso 2017); Harlan County: (40.015N, -99.363W), 3 UNSM (Johnson and Geluso 2017). Sheridan County: (42.684N, -102.690W), 1 UNSM (Benedict et al. 2000), (42.717N, -102.464W), 3 UNSM (Benedict et al. 2000). OKLAHOMA: Pushmataha County: (34.551N, -95.345W), 1 UCOCV (Braun et al. 2020).

Unpublished museum specimens (14).—CANADA: BRITISH COLUMBIA: (51.650N, -118.618W), 2 UAM, (57.238N, -122.685W), 1 UAM, (59.475N, -123.198W), 1 RBCM. USA: KANSAS: Ellis County: (38.875N, -99.347W), 1 FHSM, (39.102N, -99.352W), 1 FHSM; Graham County: (39.362N, -99.649W), 1 FHSM; Phillips County: (39.685N, -99.234W), 1 FHSM; Rooks County: (39.438N, -99.340W), 1 FHSM, (39.554N, -99.265W), 1 FHSM; Russell County: (38.876N, -98.736W), 1 FHSM, (39.114N, -98.918W), 3 FHSM.

Literature records reported by Benedict (2004) (1).—NEBRASKA: Sheridan County: (42.717N, -102.464W), 1.

Literature records reported by Caceres and Pybus (1997) (13).—CANADA: ALBERTA: (53.216N, -114.983W), 1, (53.550N, -113.466W), 1, (53.583N, -116.433W), 3, (53.583N, -116.416W), 1, (53.666N, -118.000W), (53.833N, -113.333W), 1, (55.333N,

-112.333W), 1, (55.500N, -115.683), 1, (55.783N, -118.833W), 1, (57.166N, -111.616W), 1, (59.666N, -112.316W), 1.

Literature records reported by Johnson and Geluso (2017) (1).—NEBRASKA: Harlan County: (40.013N, -99.367W), 1.

Literature records reported by Jordan (2020) (19).—NORTH CAROLINA: Bertie County: (35.971N, -77.139W), 1, (35.960N, -77.148W), 1, (35.965N, -77.149W), 1, (35.971N, -77.142W), 1; Bladen County: (34.711N, -78.521W), 2; Carteret County: (34.778N, -76.962W), 1; Columbus County: (34.159N, -78.468W), 1; Craven County: (35.007N, -77.074W), 1, (35.027N, -77.046W), 1, (35.027N, -77.046W), 1, (34.808N, -77.079W), 2; Martin County: (35.884N, -77.144W), 1; Pender County: (34.464N, -78.171W), 1; Tyrell County: (35.886N, -76.133W), 1, (35.875N, -76.131W), 1.

Literature records reported by Jung et al. (2006) (3).—CANADA: YUKON: (60.126N, -124.064W), 3.

Literature records reported by Lausen et al. (2008) (5).—CANADA: YUKON: (60.183N, -129.036W), 5.

Literature records reported by Alberta Sustainable Resource Development and Alberta Conservation Association (2009) (17).—CANADA: ALBERTA: (52.310N, -113.080W), 1, (52.750N, -111.170W), 1, (53.460N, -112.810W), 1, (55.000N, -119.000W), 1, (55.660N, -111.140W), 1, (55.810N, -111.330W), 1, (56.410N, -110.860W), 1, (56.670N, -118.000W), 1, (56.690N, -111.980W), 1, (56.950N, -111.510W), 1, (57.070N, -111.920W), 1, (57.170N, -111.540W), 1, (57.310N, -110.500W), 1, (57.560N, -110.700W), 1, (57.790N, -115.340W), 1, (58.300N, -119.290W), 1, (58.680N, -118.680W), 1.

Literature records reported by Morris et al. (2009) (1).—NORTH CAROLINA: Washington: (35.828N, -76.675W), 1.

Literature records reported by Schmidly and Bradley (2016) (1).—TEXAS: Dimmit County: (28.412N, -99.813W), 1.

Literature records reported by White et al. (2018) (2).—SOUTH CAROLINA: Beaufort County: (32.183N, -80.892W), 2.

Literature records reported by Wilkinson et al. (1995) (1).—CANADA: BRITISH COLUMBIA: (59.420N, -126.115W), 1.

***Nycticeius humeralis* (Rafinesque, 1818)**
Evening Bat

Nycticeius humeralis is found throughout the eastern United States as far north as Iowa, Wisconsin, Michigan, and Pennsylvania and westward to the Great Plains of South Dakota, Nebraska, Kansas, Oklahoma, and Texas (Hall 1981). The southern portion of its distribution in the United States reaches the Gulf of Mexico and extends down the eastern coastline of Mexico. *Nycticeius humeralis* inhabits hardwood and pine forests where they roost in trees, attics, and old barns (Watkins 1971). During the winter, northern populations of *N. humeralis* will migrate southward, whereas at least some southern populations do not migrate (Humphrey and Cope 1968; Boyles and Robbins 2006).

Andersen et al. (2017) provided a thorough update on the current distribution of *N. humeralis* noting their overall westward range expansion. Therefore, a summary of movements is not provided here as in the other accounts. However, since this publication, several notable records have been reported which expand the range of *N. humeralis* northward in Iowa, Minnesota, and Wisconsin (Fig. 3). Field work by Benedict et al. (2020) produced specimens of *N. humeralis* in northcentral Iowa. The first specimen of *N. humeralis* in Minnesota was captured in 2016 at the Minnesota National Guard training site in Arden Hills (Minnesota Department of Natural Resources 2023). Similarly, the first specimen of *N. humeralis* in Wisconsin was captured in 2015 at the Avon Bottoms State Wildlife Area (Kaarakka et al. 2018). An additional three individuals were captured at the same site in 2016. Finally, in western Texas new county records are provided for *N. humeralis* from Knox, Lubbock, Ochitree, Taylor, and Wichita counties.

Previously published museum specimens (50).—KANSAS: Stanton County: (37.523N, -102.013W),

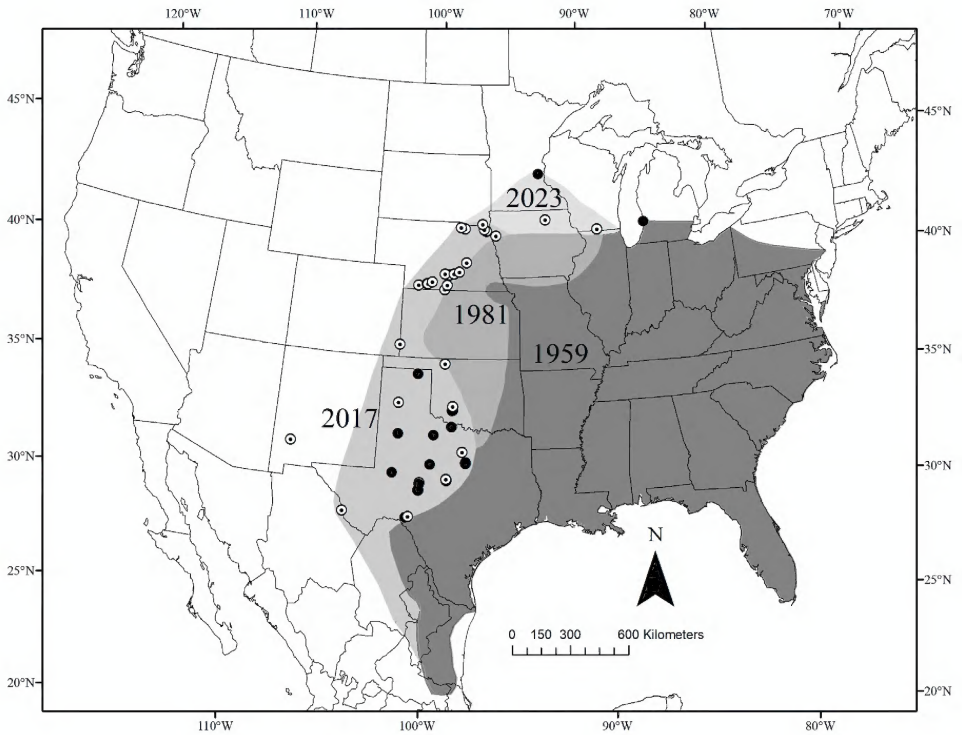

Figure 3. Distribution of the Evening Bat (*Nycticeius humeralis*) in North America showing the historic range limits proposed by Hall and Kelson (1959), Hall (1981), and Andersen et al. (2017), as well as the current range (2023). Enclosed circles represent previously published records and black dots represent unpublished museum records. The single record from New Mexico was not included in the distribution proposed by Andersen et al. (2017) due to its geographic location and was considered an extralimital record by the authors.

1 FHSM (Phelps et al. 2008). NEBRASKA: Buffalo County: (40.685N, -99.393W), 1 UNSM (Johnson and Geluso 2017), (40.708N, -98.792W), 3 UNSM (Johnson and Geluso 2017); Dixon County: (42.594N, -96.710W), 1 UNSM (Benedict et al. 2000), (42.603N, -96.716W), 1 UNSM (Benedict 2004), (42.651N, -96.874W), 1 UNSM (Benedict 2004); Franklin County: (40.207N, -99.212W) 2 UNSM (Johnson and Geluso 2017); Furnas County: (40.327N, -100.190W), 1 UNSM (Johnson and Geluso 2017); Hall County: (40.791N, -98.465W), 1 UNSM (Johnson and Geluso 2017); Harlan County: (40.013N, -99.365W), 5 MSB (Geluso et al. 2008); Hitchcock County: (40.163N, -101.057W), 1 UNSM (Johnson and Geluso 2017); Kearney County: (40.657N, -99.084W), 3 UNSM (Johnson and Geluso 2017); Knox County: (42.692N, -98.133W), 1 UNSM (Benedict 2004), (42.733N, -98.415W), 1 UNSM (Benedict 2004); Merrick County: (41.203N, -98.003W), 1 NTSRV (Benedict et al. 2000); Red Willow County: (40.235N, -100.530W), 1 NTSRV (Serbousek and Geluso 2009), (40.237N, -100.469W), 2 UNSM (Serbousek and Geluso 2009). NEW MEXICO: Grant County: (32.894N, -107.993W), 1 MSB (Andersen et al. 2017). OKLAHOMA: Kiowa County: (34.876N, -98.648W), 2 OMNH (Braun et al. 2020); Major County: (36.751N, -99.192W), 1 UWBM (Braun et al. 2020). TEXAS: Brown County: (31.595N, -98.903W), 1 ASNHC (Ammerman et al.

2012), (31.641N, -98.918W), 1 ASNHC (Ammerman et al. 2012), (31.643N, -98.937W), 4 ASNHC (Ammerman et al. 2012); Hood County: (32.396N, -97.842W), 7 TTU (Demere et al. 2012); Parker County: (32.871N, -98.042W), 1 ASNHC (Ammerman et al. 2012); Presidio County: (30.012N, -104.685W), 1 ASNHC (Dowler et al. 1999); Randall County: (34.966N, -101.897W), 1 ASNHC (Riedle and Matlack 2013); Tom Green County: (31.135N, -100.485W), 1 ASNHC (Dowler et al. 1992), (31.464N, -100.437W), 1 ASNHC (Dowler et al. 1992); Val Verde County: (29.926N, -100.987W), 1 ASNHC (Dowler et al. 1999)

Unpublished museum specimens (36).—MICHIGAN: Allegan County: (42.728N, -86.206W), 1 EMU. OKLAHOMA: Comanche County: (34.701N, -98.680W), 2 OMNH, (34.716N, -98.641W), 1 OMNH, (34.733N, -98.679W), 1 OMNH. TEXAS: Hood County: (32.430N, -97.832W), 5 ASNHC; Knox County: (33.606N, -99.741W), 1 ASNHC; Lubbock County: (33.610N, -101.821W), 2 ASNHC; Midland County: (31.869N, -102.032W), 1 ASNHC; Ochiltree County: (36.278N, -100.816W), 2 ASNHC; Taylor County: (32.301N, -99.890W), 1 ASNHC; Tom Green County: (31.404N, -100.462W), 1 ASNHC, (31.124N, -100.512W), 2 ASNHC, (31.133N, -100.500W), 1 ASNHC (31.135N, -100.494W), 1 ASNHC, (31.136N, -100.493W), 1 ASNHC, (31.146N, -100.501W), 4 ASNHC, (31.147N, -100.500W), 1 ASNHC; Val Verde County: (29.893N, -101.152W), 1 ASNHC; Wichita County: (33.988N, -98.704W), 7 ASNHC.

Literature records reported by Benedict et al. (2020) (2).—IOWA: Floyd County: (43.060N, -92.790W), 1; Woodbury County: (42.387N, -96.084W), 1.

Literature records reported by Kaarakka et al. (2018) (4).—WISCONSIN: Rock County: (42.551N, -89.358W), 4.

Literature records reported by Lane et al. (2003) (1).—SOUTH DAKOTA: Clay County: (42.894N, -96.983W), 1.

Literature records reported by Minnesota Department of Natural Resources (2023) (1).—MINNESOTA: Ramsey County: (45.081N, -93.166W), 1.

ORDER EULIPOTYPHLA
Family Soricidae
***Cryptotis parvus* (Kerr, 1792)**
Least Shrew

Cryptotis parvus (previously *parva*) is found throughout the eastern United States as far north as Iowa, Wisconsin, Michigan, New York, and Connecticut; and westward to the Great Plains of South Dakota, Colorado, Kansas, Oklahoma, and Texas (Hall 1981). The southern portion of its distribution in the United States reaches the Gulf of Mexico and extends down through eastern and central Mexico into the Central American countries of Guatemala, Honduras, Nicaragua, Costa Rica, and Panama. *Cryptotis parvus* occurs in a variety of habitats throughout its geographic range including grasslands, brushy fields, wetlands, marshes, and forests (Whitaker 1974).

Extralimital records of *C. parvus* show this species primarily expanding its range westward in Mexico and the central United States (Fig. 4). There is also some moderate northward movement in South Dakota. For instance, Backlund (2002) reported that before 1992 only two specimens of *C. parvus* were known from South Dakota in the south-central part of the state. Using a combination of field trapping, voucher specimens, literature search, and personal communication, he was able to expand the range of *C. parvus* into western and north-central South Dakota. In Nebraska, extralimital records were first observed in central Nebraska (Manning and Geluso 1989). Since then, additional field work has expanded the range of *C. parvus* into the western panhandle of Nebraska (Benedict et al. 2000, Geluso et al. 2004, Merlino et al. 2012) and eastern Wyoming (Marquardt et al. 2006).

Cryptotis parvus was known from northeastern Colorado prior to 1981 (Hall 1981), but various collecting efforts located populations in southeastern Colorado (Choate and Reed 1988; Siemers et al. 2006), just across the border in southwestern Kansas (Choate and Reed 1988), and the western panhandle of Oklahoma (Dalquest et al. 1990). In Texas, *C. parvus* has expanded its range into the western panhandle and central regions of the state (Owen and Hamilton 1986; Jones et al. 1993). This expansion proceeded westward into New Mexico

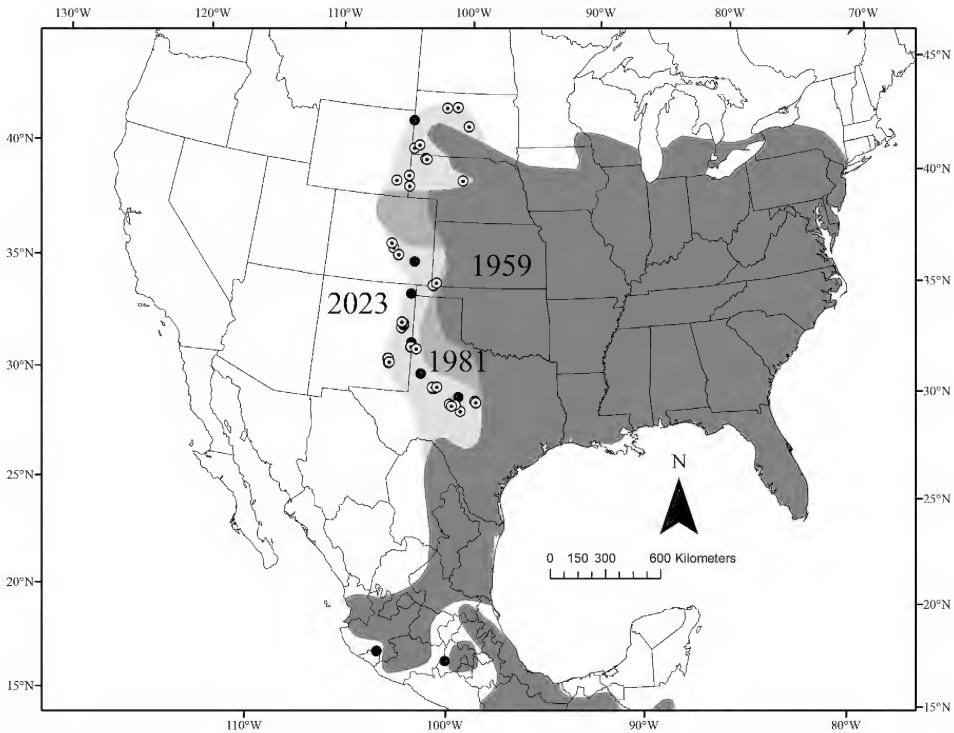

Figure 4. Distribution of the Least Shrew (*Cryptotis parvus*) in North America showing the historic range limits proposed by Hall and Kelson (1959) and Hall (1981), as well as the current range (2023). Enclosed circles represent previously published records and black dots represent unpublished museum records.

where several specimens have been collected at various sites along the eastern border of the state (Hoditschek et al. 1985; Owen and Hamilton 1986; Hafner and Shuster 1996). It is worth noting that Hafner and Shuster (1996) suggested some of these records may represent relict populations. In southcentral Mexico, museum records indicate westward movements in the states of Colima and State of Mexico.

Previously published museum specimens (144).—COLORADO: Baca County: (37.008N, -101.890W), 10 FHSM (Choate and Reed 1988); El Paso County: (38.615N, -104.680W), 1 DMNS (Siemers et al. 2006), (38.817N, -104.830W), 1 UCM (Siemers et al. 2006); Pueblo County: (38.298N, -104.320W), 1 DMNS (Siemers et al. 2006), (38.314N, -104.300W), 1 DMNS (Siemers et al. 2006). KANSAS: Morton County: (37.008N, -101.930W), 12 FHSM (Choate and Reed 1988), (37.120N, -101.700W), 1 FHSM (Choate and Reed 1988). NEBRASKA: Banner County: (41.509N, -103.960W), 3 UNSM (Merlino et al. 2012); Dawes County: (42.830N, -103.000W), 11 UNSM (Benedict et al. 2000); Scotts Bluff County: (41.989N, -104.050W), 1 MSB (Geluso et al. 2004); Sheridan County: (42.803N, -102.900W), 2 UNSM (Benedict et al. 2000). NEW MEXICO: Chaves County: (33.283N, -104.350W), 3 MSB (Frey 2005), (33.314N, -104.330W), 1 MSB (Frey 2005), (33.315N, -104.330W), 2 MSB (Frey 2005), (33.431N, -104.410W), 1 MSB (Frey 2005), (33.443N, -104.410W), 1 MSB (Frey 2005), (33.452N, -104.400W), 2 MSB (Hafner and Shuster 1996), (33.458N, -104.400W), 1 MSB (Hafner and Shuster 1996), (33.459N, -104.400W), 1 MSB (Hafner and Shuster 1996), (33.462N, -104.410W),

2 MSB (Frey 2005), (33.463N, -104.410W), 2 MSB (Frey 2005), (33.465N, -104.400W), 4 MSB (Frey 2005), (33.474N, -104.410W), 16 MSB (Frey 2005), (33.475N, -104.400W), 1 MSB (Hafner and Shuster 1996), (33.480N, -104.430W), 2 MSB (Frey 2005); Quay County: (34.957N, -103.730W), 3 NTSRV (Hoditschek et al. 1985), (35.093N, -103.610W), 1 MSB (Frey 2005), (35.117N, -103.690W), 1 MSB (Hafner and Shuster 1996), (35.145N, -103.610W), 9 MSB (Frey 2005), (35.172N, -103.710W), 1 MSB (Hoditschek et al. 1985), (35.179N, -103.710W), 2 MSB (Hoditschek et al. 1985), (35.180N, -103.700W), 1 MSB (Frey 2005), (35.181N, -103.700W), 1 NMMNHS (Hafner and Shuster 1996), (35.181N, -103.700W), 21 MSB (Frey 2005), (35.210N, -103.740W), 2 MSB (Frey 2005); Roosevelt County: (34.092N, -103.080W), 1 TTU (Owen and Hamilton 1986), (34.083N, -103.050W), 2 MSB (Hafner and Shuster 1986), (34.089N, -103.080W), 2 MSB (Hafner and Shuster 1986), (34.097N, -103.050W), 1 MSB (Fry 2005). SOUTH DAKOTA: Dewey County: (45.262N, -100.890W), 4 KU (Backlund 2002); Fall River County: (43.267N, -103.850W), 1 KU (Backlund 2002), (43.433N, -103.480W), 1 UAM (Backlund 2002); Hughes County: (44.397N, -100.030W), 3 KU (Backlund 1995); Ziebach County: (45.212N, -101.670W), 1 KU (Backlund 2002). TEXAS: Bailey County: (34.026N, -102.720W), 1 TTU (Owen and Hamilton 1986); Concho County: (31.216N, -99.840W), 1 ASNHC (Revelez and Dowler 2001). WYOMING: Goshen County: (41.733N, -104.880W), 1 MMNH (Marquardt et al. 2006).

Unpublished museum specimens (27).—MEXICO: COLIMA: Comala County: (19.475N, -103.680W), 1 OMNH, (19.488N, -103.670W), 1 OMNH. El Valle County: (19.195N, -100.130W), 1 LSUMZ. USA: COLORADO: Bent County: (38.067N, -103.220W), 1 MSB. NEW MEXICO: Curry County: (34.303N, -103.050W), 1 MSB; Union County: (36.577N, -103.290W), 1 MSB. SOUTH DAKOTA: Lawrence County: (44.560N, -104.020W), 1 DMNS. TEXAS: Brown County: (31.709N, -98.990W), 4 TCWC, (31.630N, -98.930W), 1 ASNHC, (31.643N, -98.940W), 2 ASNHC, (31.652N, -98.930W), 1 ASNHC; Gaines County: (32.884N ,-102.350W), 2 ASNHC; Howard County: (32.217N, -101.560W), 3 ASNHC, (32.231N, -101.470W), 1 ASNHC, (32.263N, -101.590W), 1 ASNHC, (32.297N, -101.310W), 1 ASNHC; Runnels County: (31.872N, -99.990W), 1 TCWC; Tom Green County: (31.442N, -100.390W), 1 ASNHC, (31.500N, -100.170W), 1 ASNHC, (31.528N, -100.510W), 1 ASNHC.

Literature records reported by Schmidly and Bradley (2016) (3).—TEXAS: Brown County: (31.771N, -98.924W), 1; Howard County: (32.287N, -101.433W), 1; Tom Green County: (31.384N, -100.439W), 1.

Literature records reported by Manning and Geluso (1989) (1).—NEBRASKA: Thomas County: (41.901N, -100.300W), 1.

ORDER RODENTIA
Family Cricetidae
***Sigmodon hispidus* (Say and Ord, 1825)**
Hispid Cotton Rat

Sigmodon hispidus occurs throughout southeastern and southcentral portions of the United States, eastern two-thirds of Mexico, Central America, and northern South America where it reaches the southern limits of its distribution (Hall 1981). It reaches its northern limits in Virginia, Kentucky, Missouri, and Nebraska and westward to Colorado, New Mexico, and Arizona. *Sigmodon hispidus* is readily found in grasslands, roadside ditches, agricultural fields, marshes, and wetlands (Cameron and Spencer 1981).

Sigmodon hispidus has expanded its range across the northern edge of its geographic distribution (Fig. 5). In the eastern United States, extralimital records have been noted in several states. For instance, museum specimens reported herein expand the range of *S. hispidus* into northeastern Tennessee, Virginia and North Carolina. In Kentucky, Slabach and Krupa (2018) report a northward expansion of *S. hispidus* into the southeastern corner of the state.

In the central United States, *S. hispidus* has moved into northern and northeastern Missouri (Genoways and Schlitter 1967; Easterla 1968; Thompson and Finck 2013). This movement is significant because they had to cross the Missouri River to reach their current location. In Nebraska, the expansion of *S. hispidus* has been well documented. Prior to Hall (1981), *S. hispidus* was known only from the southcentral and

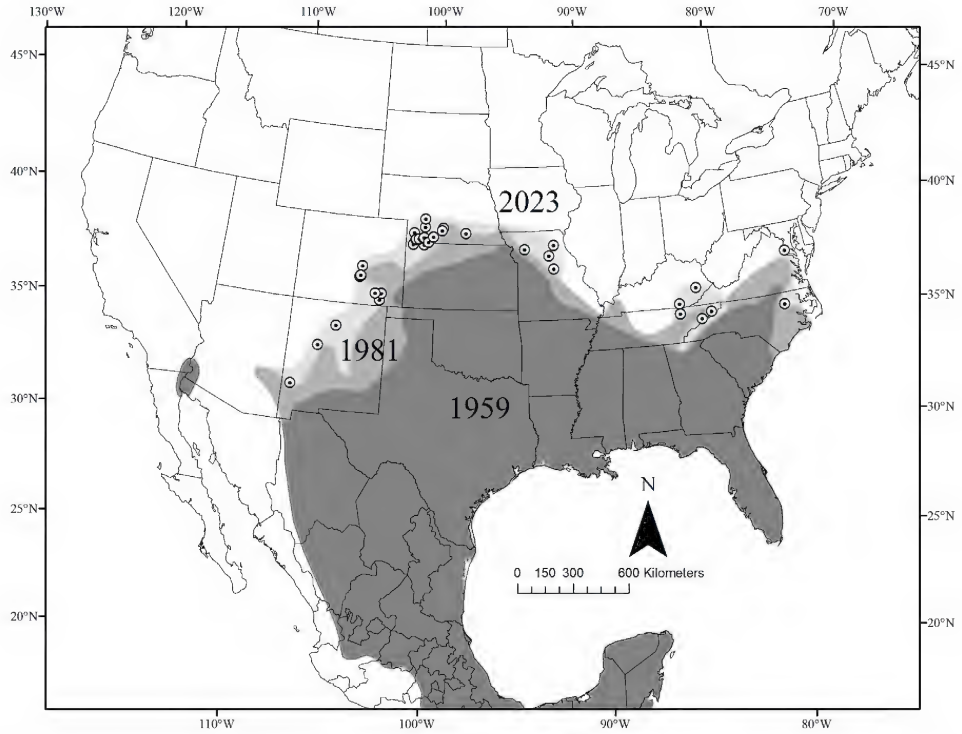

Figure 5. Distribution of the Hispid Cotton Rat (*Sigmodon hispidus*) in North America showing the historic range limits proposed by Hall and Kelson (1959) and Hall (1981), as well as the current range (2023). Enclosed circles represent previously published records and black dots represent unpublished museum records.

southeastern portions of Nebraska. Recent surveys have shown this species has been steadily moving west into southwestern Nebraska (Wright et al. 2010; Wills et al. 2011; Frisch et al. 2015; Geluso and Rohde 2021; Roehrs et al. 2021). Some of these specimens represent the northern-most records for the species (Geluso and Rohde 2021; Roehrs et al. 2021). In Kansas, *S. hispidus* occurs in all parts of the state except the northwestern corner. However, recent collecting efforts have produced voucher specimens in this area, not far from some of the recently documented specimens in Nebraska.

In the southwestern United States, *S. hispidus* has been slowly moving west in Colorado, primarily in the central and southeastern portions of the state (Mellott and Fleharty 1986). Finally, there have been some movements into southwestern and north-central New Mexico (Geluso et al. 2005; Geluso 2009). Additional museum specimens reported herein expand the range farther into north-central New Mexico.

Previously published museum specimens (43).—COLORADO: Baca County: (37.250N, -103.500W), 3 MSB (Mellot and Fleharty 1986); Pueblo County: (38.297N, -104.832W), 2 MSB (Mellott and Fleharty 1986), (38.304N, -104.850W), 6 MSB (Mellott and Fleharty 1986). KENTUCKY: (37.403N, -83.121W), 1 FMNH (Slabach and Krupa 2018); Whitley County: (36.747N, -84.276W), 4 FMNH (Slabach and Krupa 2018). MISSOURI: Boone County: (38.817N, -92.222W), 1 MUMZ (Thompson and Finck 2013); Caldwell County: (39.745N, -94.112W),

1 TTU (Thompson and Finck 2013); Pulaski County: (39.896N, -92.178W), 1 FHSM (Thompson and Finck 2013); Randolph County: (39.4284N, -92.5041W), 1 CMSU (Thompson and Finck 2013). NEBRASKA: Chase County: (40.421N, -101.513W), 2 UNSM (Wright et al. 2010); Dawson County: (40.682N, -99.566W), 1 VMUNK (Frisch et al. 2015); Dundy County: (40.113N, -101.400W), 2 UNSM (Wright et al. 2010), Hayes County: (40.700N, -100.798W), 1 UNSM (Wright et al. 2010); Hitchcock County: (40.194N, -100.866W), 1 UNSM (Wright et al. 2010), (40.222N, -100.840W), 6 UNSM (Wright et al. 2010); Nuckolls County: (40.472N, -93.032W), 1 UNSM (Wright et al. 2010); Phelps County: (40.565N, -99.640W), 1 UNSM (Wills et al. 2011); Red Willow County: (40.017N, -100.534W), 2 UNSM (Wright et al. 2010), (40.276N, -100.213W), 3 UNSM (Wright et al. 2010). NEW MEXICO: Grant County: (33.043N, -108.530W), 1 MSB (Geluso 2009); Valencia County: (34.934N, -107.134W), 2 MSB (Geluso et al. 2005).

Unpublished museum specimens (97).—COLORADO: El Paso County: (38.738N, -104.788W), 1 DMNS; Las Animas County: (37.556N, -103.431W), 8 FHSM, (37.539N, -103.820W), 1 DMNS; Pueblo County: (38.254N, -104.904W), 38 FHSM. KANSAS: Cheyenne County: (39.893N, -101.543W), 8 FHSM; Rawlins County: (39.901N, -100.814W), 15 FHSM. NEBRASKA: Dundy County: (40.125N, -101.362W), 2 UNSM; Hitchcock County: (40.154N, -101.175W), 2 UNSM, (40.221N, -100.840W), 2 UNSM; Lincoln County: (41.081N, -100.787W), 1 UNSM. NEW MEXICO: Santa Fe County: (35.904N, -106.126W), 2 MSB. NORTH CAROLINA: Edgecombe County: (36.015N, -77.692W), 1 NCSM. TENNESSEE: Campbell County: (36.292N, -84.307W), 13 OMNH; Cocke County: (35.954N, -82.975W), 1 OMNH; Unicoi County: (36.231N, -82.331W), 1 OMNH. VIRGINIA: Charles City County: (38.413N, -77.044W), 1 NCSM.

***Baiomys taylori* (Thomas, 1887)**
Northern Pygmy Mouse

The range of *B. taylori* is located from central Mexico northward in three principal directions (Hall 1981). First, *B. taylori* can be found along the eastern coast of Mexico and northward into Texas. Second, they range northward through central Mexico up into southwestern New Mexico and southeastern Arizona. Third, the distribution exists along the western coast of Mexico and reaches its northern limit in southern Sonora. *Baiomys taylori* can be found in a variety of drier habitats including coastal prairie, mid- and shortgrass prairies, desert scrub, and mixed hardwood forests (Eshelman and Cameron 1987).

Baiomys taylori has undergone an overall northward expansion of its geographic range with the most notable change in Texas (Fig. 6). Early accounts noted that *B. taylori* was moving both north and west in Texas, where it eventually reached the Llano Estacado (Jones and Manning 1989; Pitts and Smolen 1989; Choate et al. 1990). Additional museum records reported herein show that *B. taylori* occurs throughout west-central Texas. Extralimital records also are reported in northeastern Texas (Brant and Dowler 2002; Green and Wilkins 2010). New records of *B. taylori* in Oklahoma were first reported by Stangl and Dalquest (1986) with additional specimens collected by Roehrs et al. (2008) and Braun et al. (2020), all in the southwestern portion of the state. Farther east, Stevens (2015) collected the first specimen of *B. taylori* in Louisiana from the northwestern corner of the state.

Finally, *B. taylori* has been expanding its range in two regions of New Mexico. The first record of *B. taylori* was reported by Packard (1959) from southwestern New Mexico, thus Hall (1981) included this region in its distribution. Recently, new specimens have been found farther north of this range boundary (Stuart and Scott 1992; Geluso et al. 2017). In eastern New Mexico, Geluso and Geluso (2018) report the first specimens of *B. taylori*. These individuals are likely part of the populations expanding through northwestern Texas.

Previously published museum specimens (96).—LOUISIANA: Caddo Parish: 32.352N, -93.942W), 1 TTU (Stevens 2015). NEW MEXICO: Grant County: (32.431N, -108.363W), 1 WMNU (Geluso et al. 2017), (33.014N, -108.556W), 2 MSB (Geluso et al. 2017), (33.046N, -108.532W), 1 MSB (Geluso et al. 2017), (33.081N, -108.758W), 1 MSB (Geluso et al. 2017), (33.165N, -108.815W), 1 MSB (Geluso et al. 2017); Luna County: (32.579N, -107.923W), 1 MSB (Geluso et al. 2017), (32.581N, -107.919W), 2 MSB (Geluso et al. 2017), (32.587N, -107.347W), 7 MSB (Stuart and Scott 1992), (32.589N, -107.917W),

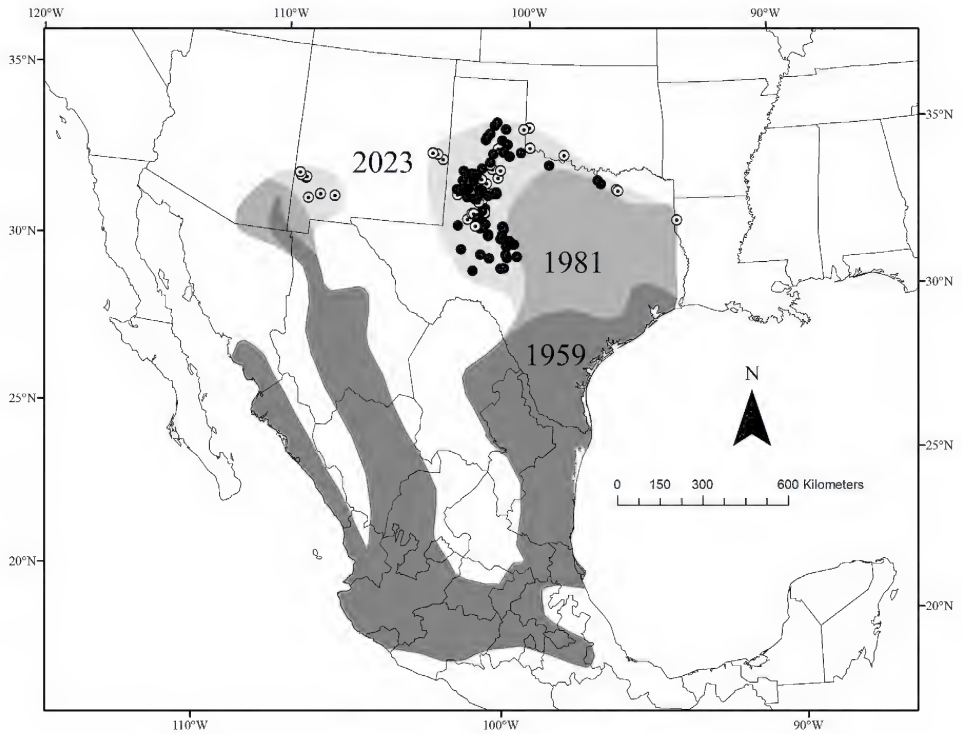

Figure 6. Distribution of the Northern Pygmy Mouse (*Baiomys taylori*) in North America showing the historic range limits proposed by Hall and Kelson (1959) and Hall (1981), as well as the current range (2023). Enclosed circles represent previously published records and black dots represent unpublished museum records.

1 MSB (Geluso et al. 2017); Roosevelt County: (33.982N, -103.227W), 8 MSB (Geluso and Geluso 2019), (34.127N, -103.445W), 1 MSB (Geluso and Geluso 2019), (34.150N, -103.650W), 1 MSB (Geluso and Geluso 2019). OKLAHOMA: Beckham County: (35.073N, -99.835W), 2 OSU (Roehrs et al. 2008); Cotton County: (34.285N, -98.401W), 1 MWSU (Stangl and Dalquest 1986); Jackson County: (34.465N, -99.776W), 2 OMNH (Braun et al. 2020). TEXAS: Borden County: (32.816N, -101.585W), 7 TTU (Choate et al. 1990); Collingsworth County: (35.016N, -100.055W), 2 TTU (Choate et al. 1990); Crosby County: (33.774N, -101.243W), 1 TTU (Choate et al. 1990); Dawson County: (32.760N, -101.705W), 1 TTU (Choate et al. 1990); Dickens County: (33.520N, -100.996W), 9 TTU (Choate et al. 1990), (33.752N,-100.918W), 3 TTU (Choate et al. 1990); Floyd County: (33.900N, -101.334W), 3 TTU (Choate et al. 1990), Gaines County: (32.958N, -102.548W), 3 TTU (Choate et al. 1990); Garza County: (33.046N, -101.377W), 2 TTU (Stangl et al. 1983), (33.054N, -101.132W), 1 TTU (Choate et al. 1990), (33.334N, -101.445W), 1 TTU (Stangl et al. 1983); Glasscock County: (32.074N, -101.666W), 2 TTU (Choate et al. 1990); Howard County: (32.460N, -101.448W), 4 TTU (Choate et al. 1990); Hunt County: (33.236N, -96.243W), 1 BU (Green and Wilkins 2010); Lubbock County: (33.455N, -101.644W), 6 TTU (Stangl et al. 1983), (33.591N, -101.888W), 1 TTU (Stangl et al. 1983), Martin County: (32.231N, -102.096W), 1 TTU (Choate et al. 1990), Martin County: (32.411N, -101.946W), 4 TTU (Choate et al. 1990), (32.413N,

-101.877W), 5 TTU (Choate et al. 1990); Midland County: (32.040N, -101.778W), 3 TTU (Choate et al. 1990); Terry County: (33.112N, -102.359W), 3 TTU (Choate et al. 1990),

Unpublished museum specimens (152).—TEXAS: Armstrong County: (34.842N, -101.409W), 2 TTU, (35.096N, -101.237W), 2 TTU; Borden County: (32.591N, -101.448W), 1 TTU; Briscoe County: (34.196N, -100.581W), 6 TTU; Carson County: (35.194N, -101.139W), 1 TTU; Coke County: (31.699N, -100.779W), 2 ASNHC, (31.703N, -100.781W), 2 ASNHC, (31.827N, -100.720W), 1 ASNHC, (31.994N, -100.671W), 1 ASNHC, (32.065N, -100.698W), 4 ASNHC, (32.067N, -100.744W), 1 ASNHC; Cooke County: (33.554N, -97.046W), 3 FHSM; Cottle County: (34.313N, -100.130W), 1 TTU; Dawson County: (32.847N, -101.835W), 1 TTU, (32.879N, -101.871W), 2 TTU, (32.895N, -101.793W), 1 TTU, (32.908N, -102.168W), 3 TTU; Donley County: (34.999N, -100.767W), 4 TTU; Floyd County: (33.984N, -101.338W), 2 TTU, (34.249N, -101.239W), 1 TTU; Garza County: (32.987N, -101.358W), 1 TTU, (33.100N, -101.046W), 2 TTU; Glasscock County: (31.823N, -101.265W), 1 TTU, (31.986N, -101.598W), 1 TTU; Grayson County: (33.452N, -96.918W), 4 FHSM; Hall County: (34.311N, -100.822W), 1 TTU, (34.327N, -100.815W), 3 TTU, (34.547N, -100.684W), 1 TTU, (34.661N, -100.897W), 1 TTU; Hockley County: (33.571N, -101.933W), 3 TTU, (33.582N, -102.069W), 1 TTU, (33.683N, -102.376W), 1 TTU; Howard County: (32.116N, -101.395W), 2 TTU, (32.209N, -101.567W), 3 TTU, (32.430N, -101.448W), 1 TTU, (32.128N, -101.547W), 1 ASNHC, (32.172N, -101.662W), 1 ASNHC, (32.252N, -101.612W), 1 ASNHC, (32.517N, -101.549W), 1 ASNHC; Irion County: (31.093N, -101.177W), 1 ASNHC; Kent County: (33.057N, -101.031W), 4 TTU; Lubbock County: (33.576N, -101.853W), 3 TTU, (33.615N, -102.042W), 1 TTU, (33.783N, -101.649W), 1 TTU; Lynn County: (33.061N, -101.612W), 3 TTU, (33.139N, -101.706W), 8 TTU, (33.394N, -101.946 W), 1 TTU; Martin County: (32.284N, -101.716W), 2 TTU, Midland County: (32.036N, -102.462W), TTU 1; Reagan County: (31.193N, -101.527W), 2 TTU; Schleicher County: (30.802N, -100.716W), 6 TTU, (30.817N, -100.631W), 2 TTU, (30.818N, -100.597W), 5 TTU; Sterling County: (31.775N, -101.260W), 1 TTU; Swisher County: (34.652N, -101.564W), 2 TTU, (34.738N, -101.528W), 1 TTU; Terrell County: (30.689N, -101.785W), 1 ASNHC; Terry County: (33.085N, -102.465W), 1 TTU; Terry County: (33.120N, -102.350W), 1 TTU, (33.154N, -102.185W), 1 TTU, (33.162N, -102.133W), 2 TTU, (33.398N, -102.378W), 1 TTU; Tom Green County: (31.229N, -100.549W), 1 TTU, (31.133N, -100.500W), 1 ASNHC, (31.183N, -100.126W), 5 ASNHC, (31.469N, -100.535W), 2 ASNHC, (31.477N, -100.548W), 2 ASNHC, (31.488N, -100.518W), 1 ASNHC, (31.526N, -100.526W), 1 ASNHC, (31.528N, -100.512W), 1 ASNHC, (31.551N, -100.248W), 2 ASNHC, (31.641N, -100.441W), 10 ASNHC; Upton County: (31.321N, -102.279W), 1 TTU; Wilbarger County: (33.968N, -98.987W), 1 KU; Wise County: (33.136N, -101.595W), 1 FHSM; Yoakum County: (33.125N, -102.597W), 1 TTU.

Literature records reported by Schmidly and Bradley (2016) (21).—TEXAS: Armstrong County: (34.937N, -101.434W), 1; Briscoe County (34.526N, -101.161W), 1; Carson County (35.457N, -101.434W), 1; Coke County (31.0828N, -100.529W), 1; Cooke County (33.667N, -97.351W), 1; Cottle County (34.159N, -100.349W), 1; Grayson County (33.706N, -96.663W), 1; Hall County (34.479N, -100.709W), 1; Hockley County (33.624N, -102.346W), 1; Irion County (31.255N, -100.891W), 1; Kent County (33.243N, -100.709W), 1; Lynn County (33.144N, -101.797W), 1; Reagan County (31.291N, -101.524W), 1; Schleicher County (30.923N, -100.529W), 1; Sterling County (31.781N, -101.071W), 1; Swisher County (34.553N, -101.797W), 1; Tom Green County (31.383N, -100.439W), 1; Upton County (31.338N, -101.981W), 1; Wilbarger County (34.068N, -99.278W), 1; Wise County (33.289N, -97.698W), 1; Yoakum County (33.211N, -102.897W), 1.

Observation records reported by Madison Grover (2021) (2).—TEXAS: Briscoe County: (34.407N, -101.046W), 2 iNaturalist.

Observation records reported by Sam Kieschnick (2019) (1).—TEXAS: Collin County: (33.278N, -96.300W), 1 iNaturalist.

Family Erethizontidae
***Erethizon dorsatum* (Linnaeus, 1758)**
North American Porcupine

Erethizon dorsatum can be found throughout western, north-central, and northeastern portions of the United States, all of Canada south of the tree line, and all of Alaska except the northern and western coastline (Hall 1981). It ranges as far south as northern Mexico, Texas, Oklahoma, Tennessee, and Virginia. *Erethizon dorsatum* inhabits a variety of habitats including boreal and eastern deciduous forest, montane habitat, desert chaparral, and grasslands interspersed with patches of wooded habitat (Woods 1973).

The most notable expansions of *E. dorsatum* have come in the south-central United States (Fig. 7). *Erethizon dorsatum* has moved steadily eastward into eastern parts of Texas (Brand et al. 2009; Goetze and Miller 2012; Schmidly and Bradley 2016) and Oklahoma (Tyler and Joles 1997; Tyler and Haynie 2001; Caire 2008; Curtis and Curtis 2014; Braun et al. 2020), yielding a statewide distribution in each state. Farther eastward, state records have been reported for Arkansas (Clark 1985) and Missouri (Alanis 2021). New records in the Mexican state of Nuevo Leon represent the eastern-most location of *E. dorsatum* in Mexico (List et al. 1999). Outside of the south-central United States and northern Mexico, extralimital records have been noted in southeastern Virginia (Moncrief and Fies 2020), northwestern Alaska, and northern California.

It is worth noting that when Hall (1981) drew his range boundaries for *E. dorsatum*, sightings were rare in many states on the periphery of its distribution. Along with the observed range expansion noted above, many states recently have been reporting increased occurrences. For instance, new county records of *E. dorsatum* have been reported throughout Kansas (Kamler and Gibson 2000; Kaufman and Kaufman 2011; Conard et al. 2016; Buckwalter and Conard 2017), Nebraska (Benedict et al. 2000), and South Dakota (Platt et al. 2009). In Illinois, Hall (1981) included the northern half of the state, but sightings were so rare that Hoffmeister (1989) did not include this species as part of the mammalian fauna. In 1998, *E. dorsatum* was observed in northern Illinois (Van Why 2009). In Virginia, *E. dorsatum* was considered extirpated even though Hall (1981) included the western and northern parts of the states within its geographic range. Moncrief and Fies (2020) documented recent evidence of *E. dorsatum* in several Virginia counties bordering West Virginia and Maryland.

Previously published museum records (7).—ARKANSAS: Sevier County: (34.038N, -94.341W), 1 UAFMC (Clark 1985). OKLAHOMA: Carter County: (34.175N, -97.263W), 1 CUMZ (Tyler and Joles 1997); Latimer County: (34.919N, -95.309W), 1 OKSU (Tyler and Joles 1997); McClain County: (35.247N, -97.600W), 1 CUMZ (Tyler and Joles 1997); Pottawatomie County: (35.258N, -96.937W), 1 CUMZ (Tyler and Joles 1997). TEXAS: Burnet County: (30.515N, -98.324W), 1 TTU (Baird et al. 2009); Webb County: (27.626N, -99.543W), 1 MWSU (Goetze and Miller 2012).

Unpublished museum records (24).—ALASKA: Northwest Arctic Borough: (67.205N, -162.492W), 1 UAM, (67.473N, -162.223W), 1 UAM. CALIFORNIA: Nevada County: (39.135N, -121.171W), 2 NTSRV; Sonoma County: (38.324N, -122.848W), 1 CAS. OKLAHOMA: Oklahoma County: (35.522N, -97.460W), 1 OMNH. TEXAS: Bandera County: (29.803N, -99.555W), 1 TTU; Blanco County: (30.098N, -98.421W), 1 MSU, (30.244N, -98.549W), 1 TTU, (30.475N, -98.378W), 1 ASNHC; Brown County: (31.612N, -98.935W), 1 ASNHC; Harris County: (29.832N, -95.764W), 1 TCWC; Kerr County: (30.194N, -99.480W), 4 TTU, (30.290N, -99.441W), 1 TTU; Tom Green County: (29.652N, -98.431W), 1 ASNHC; Travis County: (30.280N, -97.908W), 1 TTU.

Literature records reported by Caire (2008) (4).—OKLAHOMA: Canadian County: (35.532N, -97.955W), 1, (35.605N, -97.745W), 1; Oklahoma County: (35.604N, -97.352W), 2.

Literature records reported by Curtis and Curtis (2014) (1).—OKLAHOMA: Tulsa County: (36.128N, -96.087W), 1.

Literature records reported by List et al. (1999) (1).—MEXICO: NEUVO LEON: (27.233N, -100.133W), 1.

Literature records reported by Wileke (2021) (1).—MISSOURI: Pettis County: (38.689N, -93.339W), 1.

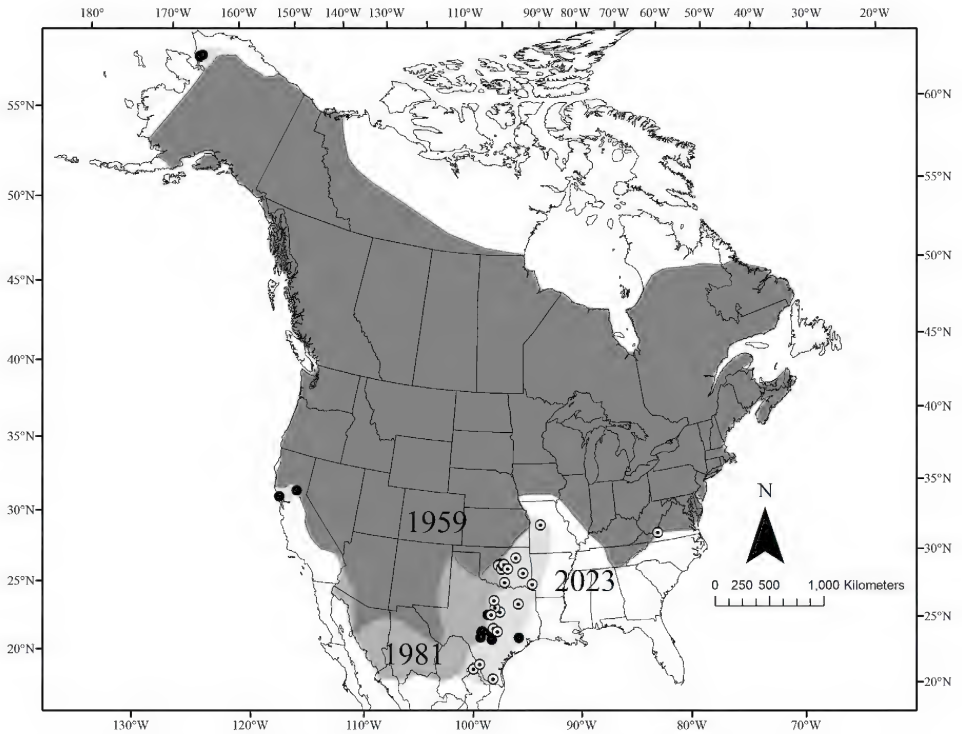

Figure 7. Distribution of the North American Porcupine (*Erethizon dorsatum*) in North America showing the historic range limits proposed by Hall and Kelson (1959) and Hall (1981), as well as the current range (2023). Enclosed circles represent previously published records and black dots represent unpublished museum records.

Literature records reported by Moncrief and Fies (2020) (1).—VIRGINIA: Montgomery County: (37.231N, -80.430W), 1.

Literature records reported by Schmidly and Bradley (2016) (6).—TEXAS: Bosque County: (31.851N, -97.698W), 1; Erath County: (32.179N, -98.221W), 1; Hidalgo County: (26.466N, -98.221W), 1; Mills County: (31.614N, -98.572W), 1; Palo Pinto County: (32.751N, -98.31W), 1; Van Zandt County: (32.494N, -95.814W), 1.

Family Sciuridae

***Marmota monax* (Linnaeus, 1758)**

Woodchuck

Marmota monax has a broad distribution throughout the eastern deciduous and northern boreal forests of North America. Its western limits include Alaska, North Dakota, South Dakota, Nebraska, Kansas, and Oklahoma, and its southern limits include Arkansas, Mississippi, Alabama, Georgia, South Carolina, and North Carolina (Hall 1981). Preferred habitats consist

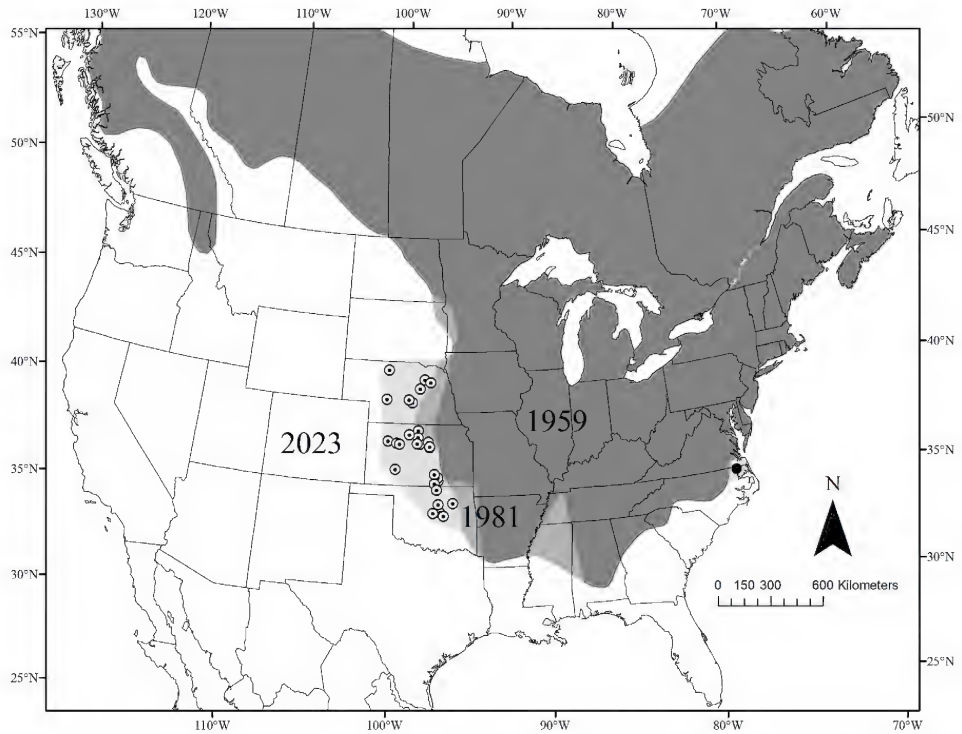

Figure 8. Distribution of the Woodchuck (*Marmota monax*) in North America showing the historic range limits proposed by Hall and Kelson (1959) and Hall (1981), as well as the current range (2023). Enclosed circles represent previously published records and black dots represent unpublished museum records.

of cultivated land, riparian woodlands, forest edges, tributary edges, fencerows, hedgerows, and shelterbelts near major rivers (Kwiecinski 1998).

Range expansion of *M. monax* generally has been westward especially in the Great Plains of the United States, with some extralimital records noted from northeastern North Carolina (Fig. 8). *Marmota monax* was historically known to inhabit Kansas and found most abundantly amongst its western distribution limit (Choate and Haner 1992). The first record of expanding *M. monax* in Kansas was reported by Black (1935). Although the range limits were unknown at the time, Black (1935) hypothesized *M. monax* was moving along rivers into Nebraska and West Kansas. Since then, *M. monax* has been moving westward across northern and south-central Kansas (Choate and Reed 1986; Choate and Haner 1992; Wilson and Choate 1996; Kaufman and Kaufman 2002; Roehrs and Genoways 2004; Kaufman et al. 2016; Everhart 2018).

The first reports of *M. monax* in Nebraska were by Thomas Say between 1819 and 1820 (Roehrs and Genoways 2004). Since then, Benedict et al. (2000) reported evidence of its expansion westward through photographs and numerous specimens found in central Nebraska. Through observational reports and additional museum specimens, Roehrs and Genoways (2004) and Forrester et al. (2019) have documented the continued westward expansion of *M. monax* across

the entire western edge of its distribution in Nebraska. Given the current rate of expansion, Forrester et al. (2019) estimated that *M. monax* could arrive in northeastern Colorado by 2024 if not there already.

In Oklahoma, *M. monax* was known only from northeastern counties prior to Hall (1981) until Caire et al. (1989) reported new specimens from north-central Oklahoma. Caire and Sloan (1996), Payne et al. (2001), and Braun et al. (2020) all reported several county records which expanded the range of *M. monax* into central Oklahoma. Previously unpublished specimens from north-central and central Oklahoma are reported herein. These findings support an eastern and northeastern distribution of *M. monax* in Oklahoma.

Previously published museum records (20).—KANSAS: Cowley County: (37.388N, -97.117W), 1 SCK (Choate and Reed 1986); (37.390N, -97.032W), 1 KU (Schmidt et al. 2021), (37.240N, -96.994W), 1 KU (Bee et al. 1981); Gove County: (39.120N, -100.553W), 1 FHSM (Schmidt et al. 2021); Jewell County: (39.664N, -98.423W), 1 FHSM (Choate and Reed 1986); Lincoln County: (39.013N, -98.317W), 1 FHSM (Schmidt et al. 2021); Ottawa County: (39.122N, -97.706W), 1 FHSM (Schmidt et al. 2021); Rooks County: (39.455N, -99.058W), 1 FHSM (Choate and Haner 1992); Sedgwick County: (37.559N, -97.258W), 1 FHSM (Everhart 2018); Sumner County: (37.098N, -97.247W), 1 KU (Choate and Reed 1986); Trego County: (39.025N, -99.935W), 1 FHSM (Wilson and Choate 1996). NEBRASKA: Antelope County: (42.129N, -98.031W), 1 VMKSC (Benedict et al. 2000); Buffalo County: (41.026N, -98.913W), 1 UNSM (Roehrs and Genoways 2004); Greeley County: (41.689N, -98.363W), 1 UNSM (Benedict et al. 2000); Lincoln County: (41.140N, -100.760W), 1 UNSM (Forrester et al. 2019); Madison County: (42.000N, -97.598W), 1 UNSM (Benedict et al. 2000); Sherman County: (41.157N, -99.154W), 1 UNSM (Roehrs and Genoways 2004). OKLAHOMA: Lincoln County: (35.703N, -96.880W), 1 UCOCV (Braun et al. 2020), (35.521N, -96.631W), 1 UCOCV (Braun et al. 2020), (35.702N, -96.880W), 1 UCOCV (Braun et al. 2020).

Unpublished museum records (1).—North Carolina: Gates County: (36.444N, -76.699W), 1 NCSM.

Literature records reported by Benedict et al. (2000) (1).—NEBRASKA: Cherry County: (42.563N, -100.677W), 1.

Literature records reported by Caire and Sloan (1996) (4).—OKLAHOMA: Kay County: (36.796N, -97.106W), 1; Oklahoma County: (35.665N, -97.326W), 1, (36.145N, -96.002W), 1; Payne County: (36.094N, -96.988W), 1.

Literature records reported by Kaufman and Kaufman (2002) (3).—KANSAS: Russell County: (39.035N, -98.478W), 1; Saline County: (38.863N, -97.612W), 1, (38.893N, -97.612W), 1.

Literature records reported by Kaufman et al. (2016) (1).—KANSAS: Osborne County: (39.334N, -98.427W), 1.

Literature records reported by Wilson and Choate (1996) (1).—KANSAS: Trego County: (38.991N, -99.737W), 1.

DISCUSSION

This research summarizes extralimital records for eight species of mammals expanding their geographic ranges throughout North America and adds to a growing body of literature documenting range expansions among various plant and animal species. One may ask, do these extralimital records represent dispersing individuals actively undergoing range expansion or simply previously undiscovered populations? To address this question, Frey (2009) suggested that it should be determined whether or not historical sampling had occurred in the area(s) where extralimital records were documented. Many of the extralimital records noted in this study came from the Great Plains of Nebraska, Kansas, Oklahoma, Texas, and New Mexico. This region has a long history of sampling for both bats and terrestrial mammals (see references herein). Given the large body of field work performed in this region over the past several decades, it seems unlikely that a majority of the records reported herein had gone undiscovered.

The results show that four species discussed in this paper are moving westward and included *M. septentrionalis*, *N. humeralis*, *C. parvus*, and *M. monax*. Westward range expansion has been documented in other mammals such as *L. borealis* (Solick et al. 2020), *P. subflavus* (Geluso et al. 2005), and *D. virginiana* (Walsh and Tucker 2018). The general consensus among the published literature is that westward moving species are using riparian corridors and other wooded areas as dispersal corridors (Benedict et al. 2000; Roehrs and Genoways 2004; Andersen et al. 2017; Johnson and Geluso 2017). Presence of such corridors are primarily the result of 19th and 20th century wildfire suppression as well as damming of rivers that reduced flooding and ice flows (Johnson 1994). This practice has allowed woody vegetation to establish along rivers, creeks, and streams, potentially allowing species from eastern deciduous forests to encroach westward.

Species expanding exclusively to the north include *B. taylori* and *S. hispidus*, with *N. humeralis* moving both north and west. Other mammals that have been moving northward include *D. novemcinctus* (Taulman and Robbins 1996, 2014), *L. seminolus* (Perry 2018), and *D. virginiana* (Myers et al. 2009; Walsh and Tucker 2018). Most evidence suggests that northward movements are in response to warming temperatures linked to human activities (Myers et al. 2009). It is believed that industrial-era warming was evident in oceans and on continents as early as the mid-1800s (Abram et al. 2016). Movements of *B. taylori* were first documented in Texas in 1887 and new northerly records have been reported consistently, especially since the 1950s to present (Pitts and Smolen 1989; Braun et al. 2020). Northward movements of *S. hispidus* were noted as early as 1933 in Kansas (Cockrum 1948) and 1939 in Tennessee (Kellogg 1939), with new northerly records continuing to be documented (Frisch et al. 2015; Slabach and Krupa 2018). Additionally, corridors with grassy habitats were being built during this time in the form of right-of-ways associated with powerlines, paved roads, and railroads. These linear structures may have provided a means for *B. taylori* and *S. hispidus* to disperse northward (Mellott and Fleharty 1986; Choate et al. 1990; Slabach and Krupa 2018).

Only one species, *M. nivalis*, was found to be broadly expanding its range southward. Other species moving south, such the Meadow Vole (*Microtus pennsylvanicus*; Frey and Moore 1990), Masked Shrew (*Sorex cinereus*; Benedict et al. 2000), and Southern Bog Lemming (*Synaptomys cooperi*; Campbell et al. 2010), appear to be only localized movements with no evidence of widespread expansion along the southern edge of their distributions. Frey (1992) hypothesized that the southern expansion of *M. nivalis* was due to the Great Plains experiencing cool, moist conditions over the past several decades. It is uncertain whether similar conditions persist in areas of Kentucky, Tennessee, and Virginia where *M. nivalis* is also expanding southward. Hoofer and Choate (1997) suggested *M. nivalis* is moving south through the Great Plains because it encountered a new food source in the northward moving *S. hispidus*. While this hypothesis remains untested, it is worth pointing out that *S. hispidus* also has been moving northward in the same areas of Kentucky, Tennessee, and Virginia where *M. nivalis* is moving south.

This research identified *E. dorsatum* as a species expanding eastward. There is a paucity of information regarding species moving eastward in North America, even at a local scale. Other species that appear to be broadly expanding to the east include the Mountain Lion (*Puma concolor*; LaRue et al. 2012) and Coyote (*Canis latrans*; Hody and Kays 2018). In the case of *P. concolor*, it was extirpated from central North America in the early 1900s and now appears to be recolonizing this area. Although records of *E. dorsatum* are known from most parts of Nebraska, Kansas, and Oklahoma (Hall 1981), it probably was never common in these areas (Cockrum 1952; Jones 1964; Caire et al. 1989). Hypotheses for this eastward expansion include the increase of woody vegetation, especially along riparian corridors, due to wildfire suppression and damming of rivers (Johnson 1994; Tyler and Joles 1997; Benedict et al. 2000).

The continued monitoring of changes to species distributions provides valuable information to researchers and wildlife managers. New species entering states and provinces will ultimately lead to novel ecological interactions and increases the potential for the spread of wildlife diseases. Further, as climate change continues to impact our environment, the need for this information is necessary to understand the dynamics of species distributions and highlights the importance of natural history databases, which are necessary tools for tracking these changes.

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Publications of the Museum of Texas Tech University

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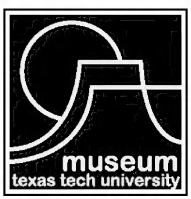

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Erratum

9 March 2023

Barnes, E. F., and J. D. Hoffman. 2023. Significant range extensions of eight species of North American mammals. Occasional Papers, Museum of Texas Tech University 385:1-29.

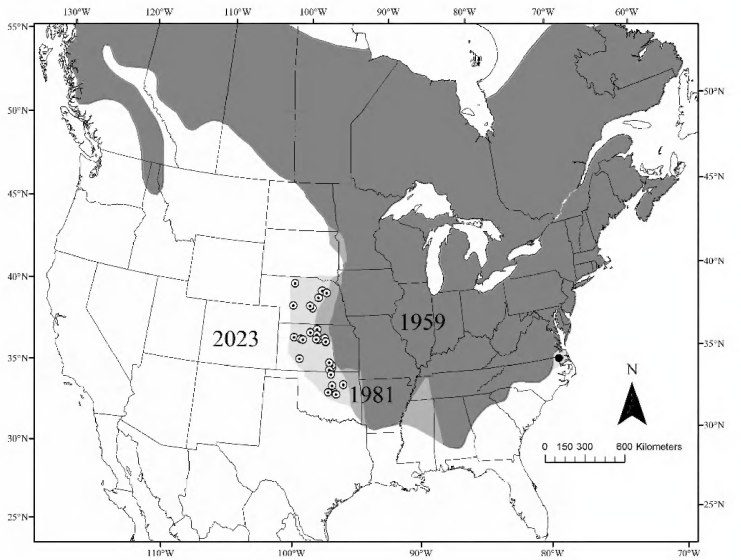
An erroneous record for the Woodchuck, *Marmota monax*, was reported on pages 19 and 20 of this publication. The online PDF for this OP has been corrected to remove this record. Please discard any previously downloaded PDF of OP 385, and download this corrected version.

If you obtained reprints of this OP from the publisher or from the author, please insert this erratum page into all copies.

The authors and the editors of the *Occasional Papers* series sincerely apologize for this oversight and this inconvenience.

Corrections made to OP 385 are as follows:

1) Page 19: replaced Figure 8 with this map.



2) Page 19, second paragraph, 4th line: deleted the text “southern Alaska and”.

3) Page 20, *Unpublished museum records*: changed number of records from “2” to “1”, and deleted the record “ALASKA: Anchorage Borough: (61.141N, -149.861W), 1 UAM.”

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